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DIFFUSION IN A FIELD OF STATIONARY TURBULENCE

By

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DRAFT TRANSLATION

title all caps

DIFFUSION IN A FIELD OF STATIONARY TURBULENCE* [see below]

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Comtes-Rendus de
l'Académie des Sciences,
Mécanique des Fluides
T. 257, No. 17, pp. 2395-6
Paris, 21 October 1963

~~by~~ M. Jean Gosse

The experimental study of heat or matter scattering from a point source placed on the axis of a tube shows that the diffusion coefficient is, for a given regimen, equal to the kinematic viscosity-by turbulence factor [1]. When for that same type of flow the wall is the source of heat, it may be noted that in the region close to tube axis (at one third of the radius), the diffusion coefficient is almost twice as great as formerly [2].

The object of the present Note is to explain this experimental result by reverting to a theoretical study [3], according to which:

— (1) the fluid's diffusion coefficient is in itself equal by turbulence at each point to the kinematic viscosity by turbulence ν_t.

— (2) a gradient of ν_t has for consequence a diffusion yield of fluid such that the mass, traversing during the unit of time a unitary normal surface to Oy is equal to $-\rho\,(d\nu_t/dy)$, ρ denoting the specific mass of the fluid. The author establishes that this flux is without sensible effect on the quantity of motion transfer.

According to numerous experiments, the case of turbulent regimen established in a conduit, corresponds to an independent

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all caps

* [Diffusion dans un champ de turbulence stationnaire] - Note transmitted by M. Léopold Esande.

velocity profile of the measurement cross section and to a variable coefficient ν_t in a direction perpendicular to the wall.

However, those two statements are irreconcilable if one refers to the theoretical conclusion (2). We must therefore admit that there exists an adverse flux, related to the turbulent state of the fluid [4]. Thos two antagonistic fluxes are such, that their resultant at each point of the space is zero under the angle of the macroscopic mass balance. We take up here this hypothesis by considering the fluid as a homogenous phase containing the entity A (heat or matter in dilution) in volume concentration C_A. The direction Oy is perpendicular to the axis of the wall.

Let us compute the quantity A which accumulates in the unit of volume in a unit of time becuase, on the one part, of the diffusion proper, of coefficient ν_t according to (1), and on the other on account of the adverse current having, according to (2) for a component of the velocity $d\nu_t/dy$:

$$-\frac{d}{dy}\left(\nu_t \frac{dC_A}{dy}\right) - \frac{d\nu_t}{dy}\frac{dC_A}{dy} = -\frac{d}{dy}\left(2\nu_t \frac{dC_A}{dy}\right) + \nu_t \frac{d^2 C_A}{dy^2}.$$

To the extent that the very last term is negligible relative to that accomanying it, we must not that the two fluxes across a fictive initary surface perpendicular to the direction Oy have the same effect upon the quantity A, so that the apparent diffusion coefficient of A is equal to $2\nu_t$. This would correspond for a thermal problem to a prandtl number by turbulence $Pr_t = 0.5$, but let us note that this number does not have, in the general case, a simple and constant value in the cross section of the tube.

We thus manage to clarify the paradoxical appearance mentioned at the beginning of this note. The fundamental anaolgy of Reynolds, according to which, either the matter, heat or quantity of motion diffuse identically is valid, but in case of a stationary heterogenous turbulence, there appears an adverse current linked to the latter, which conceals this analogy when one considers the diffusion of an entity A in this fluid.

The theory expounded refers to the results of experiments on the turbulence established in the conduits and derives a turbulent Prandtl number at tines near 0.5. As was stressed by Kestin and Richardson [2], this value is exactly the one determined in the case of free turbulence, wake of a heated cylinder or jets. Since no other hypothesis was made than that of a stationary state, a relationship is established between these two types of flows, generally considered as dissimilar.

**** THE END ****

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